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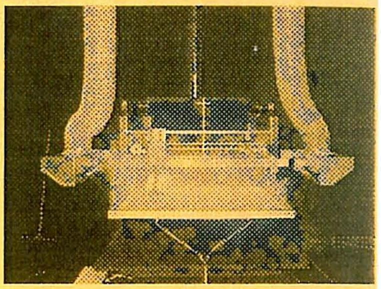
Local Exh



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Introduction

In the printing office the use of dyes and solvents often results in occupational health problems. Today, target levels for industrial air quality and acceptable worker exposure are much lower than before. This makes heavy demands on the exhaust efficiency of polluting processes as well as it focuses on worker exposure. This paper describes a process of optimisation of exhaust efficiency and of minimisation of worker exposure at a semiautomatic printing machine at a printing office.

Analysis of Exhaust Efficiency of Semiautomatic Printing Machine in a Printing Office

At the semiautomatic printing machine the distribution of dye and the printing are automatic, while feeding of printing material is done manually, see figure 1. The printing process has the following steps: 1) the worker puts printing material in the machine and starts it; 2) the printing frame is lowered 0,2 m; 3) the printing arm is moved to the right for printing and back again for distribution of dye; 4) the printing frame is raised and 5) the printing material is laid on a shelf for drying. The local exhaust consisted of one exhaust slot on each side of the printing frame, see figure 1. The exhaust was mounted on the printing frame and it moved up and down with it.

The exhaust efficiency was measured by tracer gas in the printing office under a simulated print process using a false printing frame for supply of tracer gas. The measured concentrations showed very large variations. The printing process (both machine and worker activity) had a large impact on the exhaust efficiency which in some periods was reduced considerably, especially when the printing frame was moved. The mean exhaust efficiency for a printing cycle was 65% at an exhaust volume flow rate of 410 m^3/h. The standard deviation was 12% and the maximum and minimum efficiency measured were 90% and 40%, respectively. The large variation indicates that the mean efficiency alone is not a representative measure for the working conditions.

It was concluded that an optimised exhaust system should not only raise the mean efficiency but also be less sensitive to the printing process and decrease the variations considerably to avoid situations with very low efficiencies.

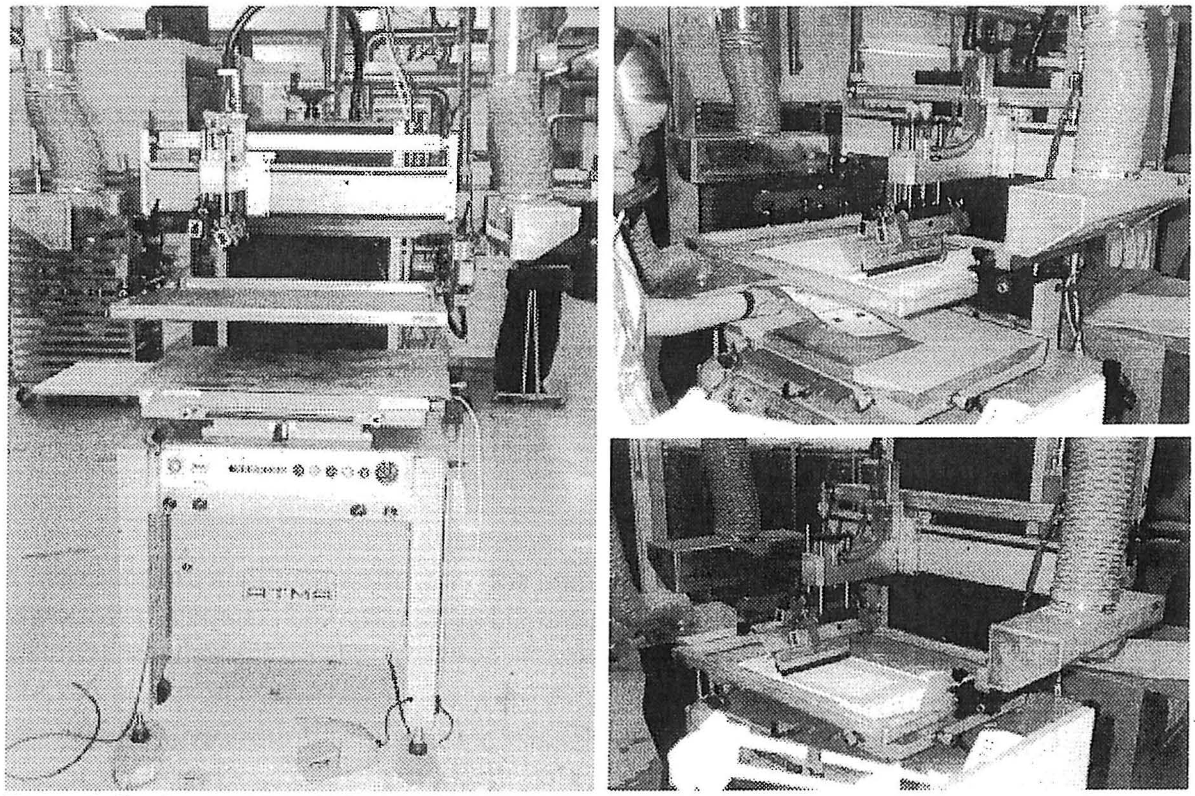

Figure 1. Semiautomatic printing machine.

Analysis of Exhaust Efficiency of Full-Scale Model Machine in the Laboratory

A full-scale model of the printing machine simulated the printing process and a living person as well as a breathing thermal manikin were used to simulate the working process. By smoke and tracer gas experiments it was verified that the laboratory model behaved as the real machine in the printing office.

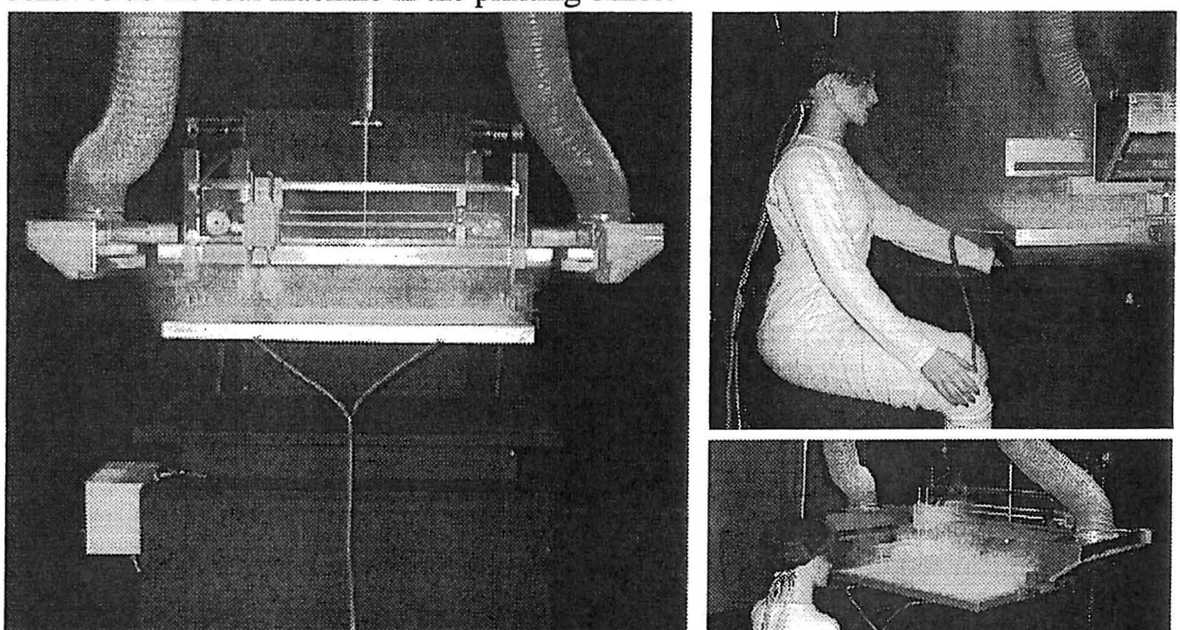

Figure 2. Full-scale laboratory set-up of printing machine and the process.

Optimisation of Exhaust Efficiency and Worker Exposure

A series of experiments with different exhaust flow rates was carried out and it showed that an increase in the mean exhaust efficiency from about 70% to about 90% would require a three times as high exhaust flow rate and would therefore not be an energy-efficient solution.

Instead the existing volume flow rate and the existing local exhaust configuration was used as a starting point for optimisation.

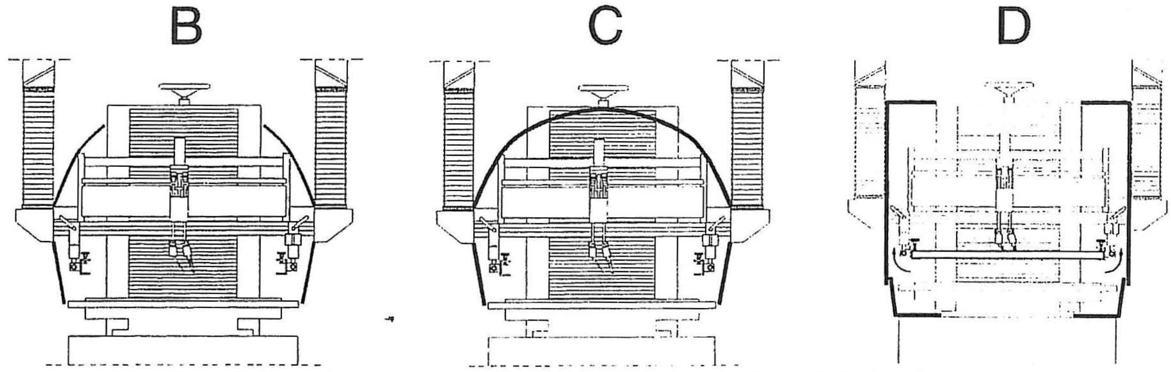

Figure 3. Sketches of three flange configurations used in optimisation of the local exhaust.

Different kinds of flange configurations were tried out, see figure 3. Also the back of the machine was covered.

As it can be seen from table 1 the local exhaust efficiency was not very different for the three configurations, but it was higher than the existing configuration, (A). However, the disturbances from the printing process still caused large differences in the values during a printing cycle.

Table 1. Exhaust efficiency for existing solution (A) and three proposed improvements (B, C and D).

	Solution A	Solution B	Solution C	Solution D
Mean Exhaust Efficiency	71	88	87	87
Standard deviation	41	24	39	44
Maximum	173	138	181	184
Minimum	37	56	41	44

Smoke tests showed that the reduction in efficiency was especially pronounced when the printing frame was lowered. In the smoke test for configuration A, the smoke was spread to all sides when the printing frame was lowered. For configurations B and C the smoke was directed towards the worker, because of the flanges. For configuration D more space was left between the flanges and the printing frame and the amount of air pushed towards the worker was reduced considerably. So, even if solutions B – D showed about the same mean exhaust efficiency the conditions and the exposure of the worker were quite different. To verify that configuration D had improved the exhaust efficiency as well as the worker exposure a series of measurements was carried out with a thermal breathing manikin that compared configuration D with the existing solution, (A). The exposure of the manikin is defined as the concentration in the inhaled air divided by the concentration in the exhaust for an exhaust efficiency of 100 %.

Table 2. Exhaust efficiency and worker exposure for the existing and the optimised solution.

	Existing Solution				*Optimised Solution*			
	Standing		*Sitting*		*Standing*		*Sitting*	
	Exh.	*Exp.*	*Exh.*	*Exp.*	*Exh.*	*Exp.*	*Exh.*	*Exp.*
Mean Efficiency	71	18	62	22	89	3	82	2
Standard Deviation	34	27	22	44	49	2	36	2
Maximum	157	98	101	137	156	6	158	8
Minimum	35	0	38	0	46	0	46	0

The results in table 2 show that the variations in the measured exhaust efficiency is just as high for the optimised solution as for the existing solution but the worker exposure has been reduced considerably. The disturbances created by the printing process do neither have an impact on the conditions close to the machine nor on the worker exposure but can be caught and contained by the flanges around the process.

Conclusion

This project has shown that in the optimisation of exhaust ventilation it is very important to take the working process of the machine as well as the worker into consideration. The working process can result in very high variations in the exhaust efficiency and a mean value is not necessarily enough to document conditions for the worker. It is therefore important to focus not only on the mean value but also on the variation in the exhaust efficiency.

It is also important to focus not only on the optimisation of the exhaust efficiency but also on the optimisation of the worker exposure. An optimised exhaust efficiency gives no guaranty for improved working conditions.

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